

## **SYNTHETIC MATERIAL AND METHODS OF FORMING AND APPLYING SAME**

### CLAIM OF BENEFIT OF FILING DATE

5           The present application claims the benefit of the filing date of U.S. Provisional Application Serial No. 60/415,511 (filed October 2, 2002), hereby incorporated by reference.

### FIELD OF THE INVENTION

10           The present invention relates to an improved synthetic material, and articles incorporating the same. More particularly, the present invention relates to a synthetic material having a tacky surface and a non-tacky surface wherein a base tacky material is treated, coated, covered or the like for forming the non-tacky surface.

### BACKGROUND OF THE INVENTION

15           It is generally known to apply a synthetic material such as an expandable material, a structural material, a foamable material or the like to an article of manufacture for imparting strength, acoustic damping characteristics or the like to  
20           the article. Such synthetic materials are frequently used in articles such as buildings, containers, automotive vehicles or the like. In certain situations, it may be desirable for one surface of such a synthetic material to be tacky while another surface of the material is substantially non-tacky, for example, to allow an individual applying the synthetic material to handle the non-tacky surface of the synthetic  
25           material while adhering the tacky surface of the material to an article. An example of such a synthetic material is disclosed in commonly owned copending application serial no. 10/217,991, filed August 13, 2002, herein expressly incorporated for all purposes. Thus, the present invention seeks to provide a novel synthetic material having at least one tacky surface and at least one substantially non-tacky surface.

### SUMMARY OF THE INVENTION

30           The present invention is directed to a synthetic material, a method of forming the synthetic material, articles incorporating the synthetic material and methods of applying or using the synthetic material. The synthetic material typically includes a

base material that is tacky at a temperature of less than about 80 °C for providing at least one tacky surface. The synthetic material may also include a substantially non-tacky surface provided by a coating, film or treatment applied to the base material. The coating, film or treatment preferably provides the substantially non-tacky surface at a temperature of up to about 40 °C, but may exhibit adhesivity at a temperature greater than 120 °C (e.g. upon activation by heat or other stimulus).

#### BRIEF DESCRIPTION OF THE DRAWINGS

The features and inventive aspects of the present invention will become more apparent upon reading the following detailed description, claims, and drawings, of which the following is a brief description:

Fig. 1 is a sectional view of an exemplary synthetic material according to one aspect of the present invention;

Fig. 2 is a sectional view of an exemplary synthetic material according to another aspect of the present invention; and

Fig. 3 is a sectional view of an exemplary synthetic material according to yet another aspect of the present invention.

#### DETAILED DESCRIPTION OF THE INVENTION

The present invention is predicated upon an improved synthetic material, articles incorporating the material and a method for forming the material. Preferably, the method enables formation of the synthetic material with a tacky surface and a substantially non-tacky surface. It is also preferable for the synthetic material to assist in providing structural reinforcement, adhesion, sealing, acoustical damping properties or a combination thereof within a cavity or upon a surface of one or more structural members (e.g., a body panel or frame member) of an article of manufacture (e.g., an automotive vehicle). The synthetic material may be applied directly to structural members of articles of manufacture or it may be applied to a first member (e.g., a reinforcing member) followed by application of the member and the material to a structural member.

Generally, the synthetic material of the present invention includes a substantially non-tacky coating, film or treatment that is applied to a tacky base material. This coating, film or treatment is applied to at least one of a plurality of

surfaces of the base material. In this manner, it is possible to form the synthetic material with at least one tacky surface and at least one substantially non-tacky surface. Preferably, the synthetic material is layered upon release paper such that a tacky surface of the synthetic material is releasably supported upon the paper.

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#### Base Material

Generally speaking, the base material of the present invention is at least partially tacky at room temperature (e.g., about 23 °C) and is also preferably tacky at temperatures between about 0 °C and about 80 °C. Additionally, the base material  
10 preferably exhibits reinforcement characteristics (e.g., imparts rigidity, stiffness, strength or a combination thereof to a member), acoustic characteristics (e.g., absorbs sound), sealing characteristics or other advantageous characteristics. It is also preferable for the base material to be heat activated to expand or otherwise activate and wet surfaces which the base material contacts. After expansion or  
15 activation, the base material preferably cures, hardens and adheres to the surfaces that it contacts. It is preferable for the coating, film or treatment to have minimal detrimental effects upon the adhesivity of the base material and it is contemplated that the coating, film or treatment may enhance the adhesivity of the base material.

Depending on the purpose of the synthetic material, it is preferable for base  
20 material to exhibit certain characteristics such that some or all of these characteristic may also be exhibited by the synthetic material. For application purposes, it is often preferable that the base material exhibit flexibility, particularly when the base material is to be applied to a contoured surface of an article of manufacture. Once applied, however, it is typically preferable for the base material to be activatable to  
25 soften, expand (e.g., foam), cure, harden or a combination thereof. For example, and without limitation, a typical base material will include a polymeric material, such as an epoxy resin or ethylene-based polymer which, when compounded with appropriate ingredients (typically a blowing and curing agent), expands and cures in a reliable and predicable manner upon the application of heat or the occurrence of a  
30 particular ambient condition. From a chemical standpoint for a thermally-activated material, the base material may be initially processed as a flowable material before curing. Thereafter, the base material preferably cross-links upon curing, which makes the material substantially incapable of further flow.

In most applications, it is undesirable for the base material to be reactive at room temperature or otherwise at the ambient temperature in a manufacturing environment (e.g. up to about 40 °C or higher). More typically, the base material becomes reactive at higher processing temperatures, such as those encountered in an automobile assembly plant. In such an embodiment, the base material may be foamed upon automobile components at elevated temperatures or at higher applied energy levels, e.g., during painting preparation steps. While temperatures (e.g., body shop temperatures or e-coat temperatures) encountered in an automobile assembly operations may be in the range of about 148.89° C to 204.44°C (about 300°F to 400°F), paint shop applications are commonly about 93.33°C (about 200°F) or slightly higher. If needed, blowing agent activators can be incorporated into the base material to cause expansion at different temperatures outside the above ranges.

Generally, suitable expandable materials or foams for the base material have a range of expansion ranging from approximately 0 to over 1000 percent. The level of expansion of the material may be increased to as high as 1500 percent or more. Typically, strength is obtained from materials that undergo relatively low expansion while materials intended for acoustic use (e.g., damping) typically undergo greater expansion.

Advantageously, the base material of the present invention may be formed or otherwise processed in a variety of ways. For example, preferred base materials can be processed by injection molding, extrusion, compression molding or with a robotically controlled extruder such as a mini-applicator. This enables the formation and creation of part designs that exceed the capability of most prior art materials.

It is contemplated that the base material may be formed of a variety of materials. For example, and without limitation, the base material may be formed primarily of plastics, thermoplastics, epoxy materials, elastomers and the like or combination thereof.

In one embodiment, the base material may be elastomer-based. In such an embodiment, the base material may include or be primarily composed of elastomers such as natural rubber, styrene-butadiene rubber, polyisoprene, polyisobutylene, polybutadiene, isoprene-butadiene copolymer, neoprene, nitrile rubber (e.g., a butyl nitrile, such as carboxy-terminated butyl nitrile), butyl rubber, polysulfide elastomer,

acrylic elastomer, acrylonitrile elastomers, silicone rubber, polysiloxanes, polyester rubber, diisocyanate-linked condensation elastomer, EPDM (ethylene-propylene diene rubbers), chlorosulphonated polyethylene, fluorinated hydrocarbons, combinations thereof and the like. In one embodiment, recycled tire rubber may be employed. Examples of suitable elastomer-based materials, which may be used as in the base material are sold under the product designations L2701, L2663, L2609 and are commercially available from L&L Products, Romeo, Michigan. According to the preferred formulations, the base material includes up to about 30 % by weight elastomers, more preferably, up to about 40 % by weight elastomers, and even more preferably up to about 60 % by weight elastomers. Of course, the preferred amount of elastomer may vary depending upon the desired application of the synthetic material.

In other embodiments, it is contemplated that the base material may be thermoplastic-based. In such an embodiment the base material may include or be primarily composed of thermoplastic materials such as polyamides, polyolefins, polyethylene, polyvinyl chlorides, polypropylene, ethylene copolymers, terpolymers and the like and combinations thereof. According to the preferred formulations, the base material includes up to about 40 % by weight thermoplastics, more preferably, up to about 60 % by weight thermoplastics, and even more preferably up to about 80 % by weight thermoplastics. Of course, like the elastomer formulations, the amount of thermoplastic may vary depending upon the desired application of the synthetic material.

In a highly preferred embodiment, the base material is epoxy-based and includes or is primarily composed of various epoxy containing materials. The base material may be formed from variety of formulations having epoxy material and preferably epoxy resin integrated therein. Epoxy resin is used herein to mean any of the conventional dimeric, oligomeric or polymeric epoxy materials containing at least one epoxy functional group. The epoxy materials may be epoxy containing materials having one or more oxirane rings polymerizable by a ring opening reaction.

The epoxy may be aliphatic, cycloaliphatic, aromatic or the like. The epoxy may be supplied as a solid (e.g., as pellets, chunks, pieces or the like) or a liquid. The epoxy may include an ethylene copolymer or terpolymer that may possess an alpha-olefin. As a copolymer or terpolymer, the polymer is composed of two or three

different monomers, i.e., small molecules with high chemical reactivity that are capable of linking up with similar molecules. One exemplary epoxy resin may be a phenolic resin, which may be a novalac type or other type resin. Other preferred epoxy containing materials may include a bisphenol-A epichlorohydrin ether polymer, or a bisphenol-A epoxy resin which may be modified with butadiene or another polymeric additive. Examples of suitable epoxy-based materials, which may be used as in the base material are sold under the product designations L5020, L5010, L5224, L8000, L5001 and are commercially available from L&L Products, Romeo, Michigan. According to preferred formulations, the base material can include up to about 50 % by weight epoxy resins, more preferably, up to about 65 % by weight epoxy resins, and even more preferably up to about 80 % by weight epoxy resins. Most preferably, the base material can include between about 45 % by weight epoxy resins or lower and about 75 % by weight epoxy resins or higher.

In preferred embodiments, a substantial portion of the materials in the base material will typically have molecular weights that are low enough to maintain adhesive capability of the base material. For an elastomer-based or epoxy-based base material, it is preferable for at least about 5 % by weight of the elastomer or epoxy materials to have a molecular weight less than about 1000 and more preferably at least about 10% by weight of the elastomer or epoxy materials have a molecular weight less than about 1000. It is also contemplated that, for maintaining adhesive capability, components such as plasticizers or processing oils may be added to elastomer-based or epoxy-based materials and particularly to the thermoplastic-based base material.

As general guidance for the base material, it is preferable that at least 1 % by weight of the components have a low enough molecular weight to be a liquid at about 23 °C. More preferably, at least 5 % by weight of the components have a low enough molecular weight to be a liquid at about 23 °C. Still more preferably, at least 10 % by weight of the components have a low enough molecular weight to be a liquid at about 23 °C.

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### Coating

According to one preferred embodiment, and referring to Fig. 2, a synthetic material 30 has a coating 32 that at least partially covers a surface 34 of a base material 36 for providing a substantially non-tacky or tack free surface 38.

5 Preferably, the coating has some adhesive properties at elevated temperatures. For example, the coating may have a glass transition or activation temperature at or near the glass transition temperature or activation temperature of the base material (e.g., greater than 120 °C). Thus, the coating may become flowable and combine with the base material such that the coating, the base material  
10 or both can expand and/or adhere to a surface of a structural member.

Generally speaking, the coating is formed by applying an admixture to the base material in a partially or substantially liquid form followed by drying the admixture to form the coating. The admixture will typically include a combination of two or more of the following components: 1) one or more thermoplastic polymers; 2)  
15 one or more epoxy resins; 3) one or more curing agents (e.g., latent curing agents); and 4) a percentage solvent.

Preferably, the thermoplastic polymers, the epoxy resins, the curing agents or a combination thereof are provided in water-based forms to form the admixture as a water-based liquid, dispersion, emulsion, solution, a combination thereof or the like.  
20 It is also preferable for the thermoplastic polymers, the epoxy resins, the curing agents or combinations thereof to correspond and/or be identical to one or more components provided in the base material. Thus, any of the components of the admixture mentioned herein may also be present in the base material.

Examples of suitable thermoplastic materials include, but are not limited to,  
25 polyamides, polyolefins, polyethylene, polyvinyl chlorides, polypropylene, ethylenes combinations thereof or the like. The thermoplastic may be provided as a solid, but it preferably provided in at least partially liquid form (e.g., as an emulsion, a dispersion or the like). In one highly preferred embodiment, an ethylene based thermoplastic copolymer such as vinyl acetate ethylene is provided as an emulsion.  
30 According to preferred formulations, the admixture for the coating includes between about 5 % and about 50 % by weight thermoplastic polymers, more preferably, between about 10 % and about 30 % by weight thermoplastic polymers, and even

more preferably between about 15 % and about 25 % by weight thermoplastic polymers.

Epoxy resin is used herein to mean any of the conventional dimeric, oligomeric or polymeric epoxy materials containing at least one epoxy functional group. The polymer-based materials may be epoxy containing materials having one or more oxirane rings polymerizable by a ring opening reaction. Preferably, the epoxy is provided as an emulsified resin. According to the preferred formulations, the admixture for the coating includes between about 5 % and about 50 % by weight epoxy resins, more preferably, between about 10 % and about 30 % by weight epoxy resins, and even more preferably between about 15 % and about 25 % by weight epoxy resins. It is also preferable for the epoxy resin to have an epoxy equivalent weight (EEW) of between about 200 and about 300, more preferably between about 220 and about 280 and even more preferably between about 240 and about 260.

The epoxy may be aliphatic, cycloaliphatic, aromatic or the like. The epoxy may be supplied as a solid (e.g., as pellets, chunks, pieces or the like) or a liquid (e.g., an epoxy resin). The epoxy may include an ethylene copolymer or terpolymer that may possess an alpha-olefin. As a copolymer or terpolymer, the polymer is composed of two or three different monomers, i.e., small molecules with high chemical reactivity that are capable of linking up with similar molecules. One exemplary epoxy resin may be a phenolic resin, which may be a novalac type or other type resin. Other preferred epoxy containing materials may include a bisphenol-A epichlorohydrin ether polymer, or a bisphenol-A epoxy resin which may be modified with butadiene or another polymeric additive.

Generally, for the coating it is preferable for the epoxy to be supplied such that the epoxy may be emulsified. In preferred embodiments, the epoxy is supplied as an emulsion or dispersion in a solvent such as water.

According to the preferred formulations, the admixture for the coating includes between about 0.0 % and about 5.0 % by weight curing agents, more preferably, between about 1.0 % and about 3.0 % by weight curing agents, and even more preferably between about 1.50% and about 1.80% by weight curing agents.

Preferably, the curing agents assist the admixture, the base material or both in curing by crosslinking of the polymers, epoxy resins (e.g., by reacting in near (e.g.,



± 10 %) stoichiometric amounts of curing agent with the epoxide groups on the resins) or both. Useful classes of curing agents are materials selected from aliphatic or aromatic amines or their respective adducts, amidoamines, polyamides, cycloaliphatic amines, (e.g., anhydrides, polycarboxylic polyesters, isocyanates, phenol-based resins (such as phenol or cresol novolak resins, copolymers such as those of phenol terpene, polyvinyl phenol, or bisphenol-A formaldehyde copolymers, bishydroxyphenyl alkanes or the like), or mixtures thereof. Particular preferred curing agents include modified and unmodified polyamines or polyamides such as triethylenetetramine, diethylenetriamine tetraethylenepentamine, cyanoguanidine, dicyandiamides and the like.

According to the preferred formulations, the admixture for the coating includes between about 20 % and about 60 % by weight solvent or cosolvent, more preferably, between about 30 % and about 50 % by weight solvent or cosolvent, and even more preferably between about 35 % and about 40 % by weight solvent or cosolvent. Various different solvents may be present such as water, toluene, benzene, xylene, alcohol, ethanol, acetone or the like. In highly preferred embodiments, the solvent is greater than 30% water, more preferably greater than 70% water and still more preferably greater than 90 % water. It is also contemplated that the solvent may be entirely water.

In various embodiment of the invention, one or more fillers may also be added to the admixture for forming the coating including, but not limited to, particulated materials (e.g., powder), beads, microspheres, or the like. Preferably, the filler includes a relatively low-density material that is generally non-reactive with the other components present in the synthetic material. Fillers may be present up to 40 % by weight of the admixture, but are more preferably between about 15 % and about 20 % by weight of the admixture.

Examples of fillers include silica, diatomaceous earth, glass, clay, nanoclay, talc, pigments, colorants, glass beads or bubbles, glass, carbon ceramic fibers and the like. The clays that may be used as fillers may include clays from the kaolinite, illite, chloritem, smectite or sepiolite groups, which may be calcined. Examples of suitable fillers include, without limitation, talc, vermiculite, pyrophyllite, sauconite, saponite, nontronite, montmorillonite or mixtures thereof. The clays may also

include minor amounts of other ingredients such as carbonates, feldspars, micas and quartz. Titanium dioxide might also be employed.

Additional fillers may include mineral or stone type fillers such as calcium carbonate, sodium carbonate or the like may be used as fillers. In another preferred embodiment, silicate minerals such as mica may be used as fillers. It has been found that, in addition to performing the normal functions of a filler, silicate minerals and mica in particular.

Depending upon the particular application, other additives such as antioxidant may also be included in the admixture in amounts typically, but not necessarily, below 2 % by weight. In one highly preferred embodiment, the admixture includes a surfactant and a mineral oil defoamer.

One preferred exemplary formulation for the admixture is given in Table I directly below. It will be appreciated for all illustrative formulae provided in Tables herein, the concentrations specified are approximate, and the scope of the present invention encompasses broader ranges encompassing the amounts recited (e.g., by +/- 10% or more).

Table I Structural Coating: Preferred Formula

<b>Ingredient</b>	<b>Percent Active</b>	<b>Total Amount in Weight %</b>	<b>Amount Active Ingredient in Wt. % active ingredient</b>
Emulsified Bisphenol A Epoxy Resin (EEW ~250) in water	62%	33.88%	34.23
VAE Emulsion in water	55%	38.40%	34.41
Calcined Clay	100%	15.81%	25.76
Nanoclay	100%	1.13%	1.84
Dicyandamide	100%	1.69%	2.75
Surfactant	100%	0.56%	0.91
Mineral Oil Defoamer	100%	0.06%	0.10
Water	0%	8.47%	0
		<b>100.00%</b>	<b>100.00%</b>

It should be understood that, according to the exemplary formulation of Table I, the percent active material indicates the percentage of the ingredient that is not water or other solvent. Thus, for example, the Emulsified Bisphenol A Epoxy Resin in Water is about 62 % epoxy resin and about 38% water.

Formation of the admixture can be accomplished according to a variety of new or known techniques. Preferably, each of the components of the admixture are substantially liquid such that the components may be combined in a container and

stirred or otherwise mixed. Typically, the admixture is formed as a material of substantially homogeneous composition. However, it is contemplated that various combining techniques may be used to increase or decrease the concentration of certain components in certain locations of the admixture.

5        For forming the coating, the admixture may be applied to the base material using a variety of techniques and protocols. According to a preferred embodiment, the admixture has a consistency similar to a conventional paint and may be applied to the base materials using techniques employed to apply paints. For example, and without limitation, the admixture may be applied to the base material by spraying,  
10        brushing, dabbing, pouring, blotting or the like.

         As an alternative, the admixture may be applied to a first material such as a release paper to form the coating on the first material followed by contacting the coating with the base material. Thereafter, the first material may be removed from the coating thereby leaving the coating on the base material.

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#### Film

         According to another preferred embodiment, and referring to Fig. 3, a synthetic material 50 has a film 52 that at least partially covers a surface 54 of a base material 56 for providing a substantially non-tacky or tack free surface 58.

20        Preferably, the film is formed (e.g., extruded) as a dry film that is substantially tack-free. The film may be rigid or semi-rigid, but is preferably substantially flexible such that the film may be rolled, folded or otherwise compacted allowing the film to be stored and applied to the base material as desired. Generally, it is desirable for the film to include components having higher molecular weights than the molecular  
25        weights of components in the base material, but similar chemical structures. Such higher molecular weights can assist the film to be substantially non-tacky at about room temperature (e.g., around 23 °C) and higher temperatures (e.g., up to about 40 °C, about 60 °C and even up to about 80 °C). Preferably, however, the film has some adhesive properties (e.g., when activated by heat or other stimuli) at elevated  
30        temperatures such as temperatures greater than about 120 °C, more preferably greater than about 140 °C and most preferably greater than 150 °C. For example, the film may have a glass transition or activation temperature at or near the glass transition temperature or activation temperature of the base material. Thus, the film

may become flowable and combine with the base material such that the film, the base material or both can expand and/or adhere to a surface of a structural member. Moreover, the film is preferably non-inert or reactive (e.g., curable) along with other components of the film or the base material.

5           The film may be formed of polymeric materials such as polyethylene (e.g., polyethylene copolymers) or other polymeric material that may be extruded as dry films. Preferably, the film includes one or more adhesion promoting components such as comonomers of acrylic acid or the like.

          According to a preferred formulation, the film includes a combination of two or  
10   more of the following components: 1) one or more polymeric materials; 2) one or more epoxy resins; 3) one or more elastomer-containing adducts; 3) one or more curing agents; and 4) one or more curing agent accelerators.

          Examples of suitable polymeric materials include, but are not limited to, acetates, ethylenes, acrylates, combinations thereof or the like. In a highly preferred  
15   embodiment, the polymeric materials include a methacrylate such as ethyl or methyl methacrylate (EMA or MMA), which may or may not be modified by another component such as glycidyl methacrylate (GMA). According to preferred formulations, the film includes between about 5 % and about 50 % by weight  
20   polymeric materials, more preferably, between about 10 % and about 30 % by weight polymeric materials, and even more preferably between about 20 % and about 25 % by weight polymeric materials.

          Epoxy resin is used herein to mean any of the conventional dimeric, oligomeric or polymeric epoxy materials containing at least one epoxy functional group. The polymer-based materials may be epoxy containing materials having one  
25   or more oxirane rings polymerizable by a ring opening reaction. The epoxy resins may be supplied as solids, liquids or combinations thereof. According to the preferred formulations, the film includes between about 5 % and about 50 % by weight epoxy resins, more preferably, between about 15 % and about 35 % by weight epoxy resins, and even more preferably between about 20 % and about 28 %  
30   by weight epoxy resins.

          The epoxy may be aliphatic, cycloaliphatic, aromatic or the like. The epoxy may be supplied as a solid (e.g., as pellets, chunks, pieces or the like) or a liquid (e.g., an epoxy resin). The epoxy may include an ethylene copolymer or terpolymer

that may possess an alpha-olefin. As a copolymer or terpolymer, the polymer is composed of two or three different monomers, i.e., small molecules with high chemical reactivity that are capable of linking up with similar molecules. One exemplary epoxy resin may be a phenolic resin, which may be a novalac type or other type resin. Other preferred epoxy containing materials may include a bisphenol-A epichlorohydrin ether polymer, or a bisphenol-A epoxy resin which may be modified with butadiene or another polymeric additive.

According to the preferred formulations, the film includes between about 0.0 % and about 5.0 % by weight curing agents, more preferably, between about 1.0 % and about 3.0 % by weight curing agents, and even more preferably between about 1.50% and about 2.50% by weight curing agents.

Preferably, the curing agents assist the film, the base material or both in curing by crosslinking of the polymers, epoxy resins (e.g., by reacting in stoichiometrically excess amounts of curing agent with the epoxide groups on the resins) or both. Useful classes of curing agents are materials selected from aliphatic or aromatic amines or their respective adducts, amidoamines, polyamides, cycloaliphatic amines, (e.g., anhydrides, polycarboxylic polyesters, isocyanates, phenol-based resins (such as phenol or cresol novolak resins, copolymers such as those of phenol terpene, polyvinyl phenol, or bisphenol-A formaldehyde copolymers, bishydroxyphenyl alkanes or the like), or mixtures thereof. Particular preferred curing agents include modified and unmodified polyamines or polyamides such as triethylenetetramine, diethylenetriamine tetraethylenepentamine, cyanoguanidine, dicyandiamides and the like.

The film may also include one or more curing agent accelerators such as a urea or an imidazole. Preferably, the film includes no more than 3% by weight curing agent accelerator, more preferably between about 0.25% and about 0.75% by weight curing agent accelerator.

In a highly preferred embodiment, an elastomer-containing adduct is employed in the film of the present invention. The epoxy/elastomer hybrid may be included in an amount of up to about 30 % by weight of the film. More preferably, the elastomer-containing adduct is approximately 5% to 25%, and more preferably is about 12% to 18% by weight of the film.

In turn, the adduct itself generally includes about 1:5 to 5:1 parts of epoxy to elastomer, and more preferably about 1:3 to 3:1 parts of epoxy to elastomer. The elastomer compound may be any suitable art disclosed elastomer such as a thermosetting elastomer. Exemplary elastomers include, without limitation natural  
5 rubber, styrene-butadiene rubber, polyisoprene, polyisobutylene, polybutadiene, isoprene-butadiene copolymer, neoprene, nitrile rubber (e.g., a butyl nitrile, such as carboxy-terminated butyl nitrile), butyl rubber, polysulfide elastomer, acrylic elastomer, acrylonitrile elastomers, silicone rubber, polysiloxanes, polyester rubber, diisocyanate-linked condensation elastomer, EPDM (ethylene-propylene diene  
10 rubbers), chlorosulphonated polyethylene, fluorinated hydrocarbons and the like. In one embodiment, recycled tire rubber is employed.

In various embodiments of the invention, one or more fillers may also be added to the film including, but not limited to, particulated materials (e.g., powder), beads, microspheres, or the like. Preferably, the filler includes a relatively low-  
15 density material that is generally non-reactive with the other components present in the synthetic material. Fillers may be present up to 60 % by weight of the film, but are more preferably between about 30 % and about 40 % by weight of the film.

Examples of fillers include silica, diatomaceous earth, glass, clay, nanoclay, talc, pigments, colorants, glass beads or bubbles, glass, carbon ceramic fibers, antioxidants, and the like. The clays that may be used as fillers may include clays  
20 from the kaolinite, illite, chloritem, smectite or sepiolite groups, which may be calcined. Examples of suitable fillers include, without limitation, talc, vermiculite, pyrophyllite, sauconite, saponite, nontronite, montmorillonite or mixtures thereof. The clays may also include minor amounts of other ingredients such as carbonates, feldspars, micas and quartz. The fillers may also include ammonium chlorides such  
25 as dimethyl ammonium chloride and dimethyl benzyl ammonium chloride. Titanium dioxide might also be employed.

Additional fillers may include mineral or stone type fillers such as calcium carbonate, sodium carbonate or the like may be used as fillers. In another preferred  
30 embodiment, silicate minerals such as mica may be used as fillers. It has been found that, in addition to performing the normal functions of a filler, silicate minerals and mica in particular.

One preferred formulation for the film is given in Table II directly below:

Table II. Structural Film

Ingredient	Amount by Weight Percentage
GMA Modified EMA	7.5
EMA (MI<2)	15
Solid Bisphenol A Epoxy Resin (Type I)	15
Solid Bisphenol A Epoxy Resin (Type IV)	6
Solid Epoxy Rubber Adduct	15
Liquid Bisphenol A Epoxy Resin	3
Calcined Clay	36
Dicyandiamide	2
Modified Imidazole	0.5

5           The film may be applied to the base material using various techniques. The film may be manually or automatically applied to the base material. In one embodiment, the film and the base material may be extruded from separate extruders at substantially the same time such that the film may be continuously layered upon the base material. Thereafter, the base material and the film may be  
10 cut to shape as desire. Alternatively, the base material may be applied to a carrier member followed by layering the film (e.g., in a pre-cut configuration corresponding to the base material) upon the base material.

#### Correspondence Components

15           In highly preferred embodiments, the components of the film or coating include one or a subset of correspondence components. As used herein, correspondence components are polymeric components in the film or coating that correspond to polymeric components present in the base material. A correspondence component may be a component in the film or coating that is  
20 substantially identical to a component in the base material. For example, the base material may include a bisphenol-A epoxy resin and the film or coating may include the exact same bisphenol-A epoxy resin as a correspondence component. Alternatively, a correspondence component may be a component of the film or coating having a substantially identical monomer or oligomer configuration to its  
25 corresponding component in the base material, but the correspondence component may have a greater or lower molecular weight or a longer or shorter polymeric chain structure. As another alternative, a correspondence component may be a

component in the coating or film that is only insubstantially different from its corresponding component in the base material (e.g., exhibits substantially the same characteristics, has at least a similar polymeric structure, but has a higher or lower molecular weight).

5           It is generally preferable for the coating or film to include a substantial proportion of correspondence components. In one embodiment, the coating or film includes at least about 30 % by weight correspondence components, more preferably at least about 60 % by weight correspondence components and even more preferably at least about 70 % by weight correspondence components.

10           Molecular weights of the correspondence components may vary across a reasonably large range. In a preferred embodiment, the molecular weights of the correspondence components are between about 1000 and about 10,000,000 and more preferably between about 10,000 and about 1,000,000. One example of  
15           suitable elastomeric correspondence component is nitrile rubber such as copolymers of acrylonitrile and butadiene, which may be supplied as a liquid or a solid and which may or may not be carboxylated. Another example of a suitable correspondence  
20           component is ethylene propylene diene monomer (EPDM) rubber, which also may be supplied as a solid or a liquid.

          In a highly preferred embodiment, the synthetic material includes a base  
20           material that is formed of an epoxy-based material and a coating or film that is formed of an epoxy-based material. In the embodiment, the coating or film is formed of a combination of two or more of the following components: 1) epoxy resin; 2) thermoplastic (preferably epoxy-based); 3) elastomer-containing adduct; 4) curing agent; 5) catalyst; and 6) curing accelerator. Preferably, the epoxy resin and/or  
25           epoxy-based thermoplastic are of sufficiently high molecular weight to be solid at about room temperature (e.g., about 23° C), but are of low enough molecular weight to be at least partially liquid at elevated temperatures.

          Again, epoxy resin is used herein to mean any of the conventional dimeric, oligomeric or polymeric epoxy materials containing at least one epoxy functional  
30           group. The polymer-based materials may be epoxy containing materials having one or more oxirane rings polymerizable by a ring opening reaction. According to the preferred formulations, the coating or film includes between about 30 % and about 95 % by weight epoxy resins, more preferably, between about 40 % and about 85 %



by weight epoxy resins, and even more preferably between about 50 % and about 75 % by weight epoxy resins. For epoxy resin coatings or film, correspondence components preferably compose at least about 50 % by weight of the coating or film, more preferably at least about 60 % by weight of the coating or film and even more preferably at least about 70 % by weight of the coating or film.

The epoxy may be aliphatic, cycloaliphatic, aromatic or the like. The epoxy may be supplied as a solid (e.g., as pellets, chunks, pieces or the like) or a liquid. The epoxy may include an ethylene copolymer or terpolymer that may possess an alpha-olefin. As a copolymer or terpolymer, the polymer is composed of two or three different monomers, i.e., small molecules with high chemical reactivity that are capable of linking up with similar molecules. One exemplary epoxy resin may be a phenolic resin, which may be a novalac type or other type resin. Other preferred epoxy containing materials may include a bisphenol-A epichlorohydrin ether polymer, or a bisphenol-A epoxy resin, which may be modified with butadiene or another polymeric additive.

Examples of suitable thermoplastics may include, but are not limited to, polyamides, polyolefins, polyethylene, polyvinyl chlorides, polypropylene, ethylene copolymers and terpolymers, combinations thereof or the like. In one highly preferred embodiment, an epoxy-based thermoplastic such as a polyhydroxyether or phenoxy resin is provided in the powder. According to preferred formulations, the coating or film includes between about 2 % and about 25 % by weight thermoplastic resin, more preferably, between about 5 % and about 15 % by weight thermoplastic resin, and even more preferably between about 9 % and about 13 % by weight thermoplastic resin.

In a highly preferred embodiment, an elastomer-containing adduct is employed in the coating or film of the present invention. The epoxy/elastomer hybrid may be included in an amount of up to about 30 % by weight of the coating or film. More preferably, the elastomer-containing adduct is approximately 3% to 20%, and more preferably is about 7% to 13% by weight of the coating or film. Additionally, the epoxy/elastomer hybrid may be a correspondence component.

In turn, the adduct itself generally includes about 1:5 to 5:1 parts of epoxy to elastomer, and more preferably about 1:3 to 3:1 parts of epoxy to elastomer. The elastomer compound may be any suitable art disclosed elastomer such as a

thermosetting elastomer. Exemplary elastomers include, without limitation natural rubber, styrene-butadiene rubber, polyisoprene, polyisobutylene, polybutadiene, isoprene-butadiene copolymer, neoprene, nitrile rubber (e.g., a butyl nitrile, such as carboxy-terminated butyl nitrile), butyl rubber, polysulfide elastomer, acrylic elastomer, acrylonitrile elastomers, silicone rubber, polysiloxanes, polyester rubber, diisocyanate-linked condensation elastomer, EPDM (ethylene-propylene diene rubbers), chlorosulphonated polyethylene, fluorinated hydrocarbons and the like. In one embodiment, recycled tire rubber is employed.

According to the preferred formulations, the coating or film includes between about 3.0 % and about 20.0 % by weight curing agents, more preferably, between about 6.0 % and about 15.0 % by weight curing agents, and even more preferably between about 8.0 % and about 10.0 % by weight curing agents.

Preferably, the curing agents assist the coating, the film, the base material or a combination thereof in curing by crosslinking of the polymers, epoxy resins (e.g., by reacting in stoichiometrically excess amounts of curing agent with the epoxide groups on the resins) or both. Useful classes of curing agents are materials selected from aliphatic or aromatic amines or their respective adducts, amidoamines, polyamides, cycloaliphatic amines, (e.g., anhydrides, polycarboxylic polyesters, isocyanates, phenol-based resins (such as phenol or cresol novolak resins, copolymers such as those of phenol terpene, polyvinyl phenol, or bisphenol-A formaldehyde copolymers, bishydroxyphenyl alkanes or the like), or mixtures thereof. Particular preferred curing agents include modified and unmodified polyamines or polyamides such as triethylenetetramine, diethylenetriamine tetraethylenepentamine, cyanoguanidine, dicyandiamides and the like. It is also contemplated that curing agent accelerators may be included in the coating or film.

#### Multi-stage Cure

According to another preferred embodiment, and referring to Fig. 4, a synthetic material 60 provides a substantially non-tacky or tack free surface 64 by partially or multi-stage curing of a base material 66. For example, a portion of the base material may be exposed to a stimulus to partially cure a portion of the base material, e.g. a cure to a predetermined depth (e.g., on the order of about 1 mil to about 2 mm), or a cure in certain regions along or within the mass of material. The

synthetic material 60 is illustrated with a partially cured portion 68 that was formed by exposing at least one portion of the surface 64 of the sealant material to ultraviolet (UV) light, UV radiation, moisture, infrared light, heat or the like from a stimulus source to cross-link or otherwise cure the partially cured portion 68. As can be seen, the remainder of the sealant material 60 forms a second portion 70, which can be cured at a later time or different location. In such an embodiment, it may be desirable to incorporate a small amount of catalyst (e.g., no greater than about 3% by weight and more preferably no greater than about 1% by weight) such as a UV activated cationic catalyst (e.g., CYRACURE UVI-6992, commercially available from The Dow Chemical Corporation). Multi-stage curing processes are also discussed in a commonly owned co-pending patent application serial no. 09/939,245, titled "Paintable Material", and herein fully incorporated by reference for all purposes.

#### Application

Generally, the synthetic material is applied to a member of an article of manufacture. The member may be a structural member (e.g., a member designed to withstand various loads) or another member. According to one preferred embodiment, the member may be part of an automotive vehicle. For example, the member might be a frame member, a body member, a bumper, a pillar, a panel, a support structure or the like of an automotive vehicle.

Preferably, the synthetic material is applied directly to a member such that the material can provide reinforcement; acoustic damping, sealing or the like to the member or adjacent members. For application, an individual or machine may remove (e.g., peel) the synthetic material from the release paper to expose its tacky surface. Thereafter, the individual or machine can place the tacky surface in contact with a member to adhere the synthetic material to the member. Once applied, the synthetic material may be activated by heat or otherwise to expand and adhere to adjacent surfaces of various members of the article of manufacture. Advantageously, the non-tacky surface of the synthetic material allows for ease of initial contact and subsequent contact (e.g. for repositioning) with the non-tacky surface for application of the synthetic material.

According to an alternative embodiment, the synthetic material may be applied to a first member (e.g., a carrier member) for forming a reinforcement

member and then the reinforcement member may be applied to a member of an article of manufacture. In the embodiment, the tacky surface of the synthetic material is adhered to a surface of a carrier member (e.g., a skeleton member) with at least one exposed and preferably substantially non-tacky surface facing at least partially away from the surface of the carrier member thereby forming the reinforcement member. Advantageously, the non-tacky surface can allow for easier placement of the reinforcement member adjacent to a structural member or for easier placement of the reinforcement member within a cavity of the structural member of an article of manufacture since the non-tacky surface does not undesirably adhere to surfaces of the structural member during placement. In a particular preferred embodiment, the carrier member could be formed of injection molded nylon, injection molded polymer, or molded metal (such as aluminum, magnesium, steel and titanium, an alloy derived from the metals, and even a metallic foam).

The preferred embodiment of the present invention has been disclosed. A person of ordinary skill in the art would realize however, that certain modifications would come within the teachings of this invention. Therefore, the following claims should be studied to determine the true scope and content of the invention.